6 Development of Remedial Alternatives

This section describes the remedial alternatives that can meet the cleanup standards presented in Section 5. To develop remedial alternatives, individual cleanup technologies were first screened to identify technologies that are implementable and effective at the site. This screening is described in detail in Appendix J and summarized in Section 6.1.

Some of the individual cleanup technologies that are implementable will need further testing to determine their effectiveness at the site. Section 6.2 describes the bench-scale testing that is taking place to determine their effectiveness.

Using the results of the technology screening, technologies that are implementable and effective at the site were grouped into remedial alternatives. Section 6.3 describes the approach that was used to group individual cleanup technologies and develop the resulting remedial alternatives presented in Section 6.4.

In Section 6.4, the remedial alternatives for the site are described. Section 6.4.1 summarizes how each technology (regardless of alternative) would be implemented at the site. Section 6.4.2 summarizes each alternative.

6.1 Technology Screening

This section summarizes the results of the screening process for individual cleanup technologies that should be suitable for cleaning up contaminated soil, groundwater, sediment and surface water at the site. Surface water cleanup was not considered separately in this screening evaluation because cleanup actions designed for sediments, soil and groundwater must also protect surface water. A detailed description of the screening process is presented in Appendix J.

Table 6-1 identifies the cleanup technologies screened and determined to be effective and implementable or to hold promise of being effective and implementable in the context of physical and chemical conditions at the site. In Section 6.4, these technologies are grouped into remedial alternatives that address all of the contamination at the site.

6.2 Bench-Scale Testing of Cleanup Technologies

Few *in situ* cleanup technologies are considered potentially effective for contaminants identified at the site and limited performance data are available for these technologies and contaminants. To determine the effectiveness of these technologies, bench-scale testing is being performed. The scope of this testing is described in the *Bench Testing Work Plan* (RETEC, 2003e). Bench-scale testing is being performed for the following cleanup technologies:

- *In situ* flushing using hot water mixed with surfactant and polymer
- *In situ* biological treatment
- *In situ* chemical oxidation using ozone

This testing commenced in May 2003 and complete results should be available in the fourth quarter of 2003. The tests are designed to measure the effectiveness of these three technologies at this site. The test results will be incorporated into the Final FS/EIS, the Cleanup Action Plan and/or the Engineering Design Report, as they are available. *Ex situ* technologies (e.g., excavation) do not require bench scale testing to determine their potential effectiveness.

6.3 Approach to Developing Remedial Alternatives

This section describes the approach used to develop site-wide remedial alternatives, using the individual cleanup technologies discussed in Section 6.1 and the cleanup levels discussed in Section 5. The remedial alternatives are described in Section 6.4.3 and evaluated in detail in Section 7. The approach to developing the suite of remedial alternatives presented herein was performed in phases, as described below:

1) Subdivide the site into "cleanup zones" based on exposure pathways, land use, and distribution and chemical composition of hazardous substances (Section 6.3.1).

2) Consider standard and conditional POCs for each affected media (Section 6.3.2).

3) Consider soil remediation levels based on exposure pathways (Section 6.3.3).

4) Combine individual cleanup technologies from Section 6.1 into a suite of remedial alternatives that meets cleanup standards (i.e., cleanup levels at various POCs) and remediation levels.

Each of these phases is described in more detail below. The resulting remedial alternatives are presented in Section 6.4.

6.3.1 Site Cleanup Zones

The concept of site cleanup zones was developed to facilitate the evaluation of remedial alternatives. The zones are based on exposure pathways, land use, and distribution and chemical composition of hazardous substances at different parts of the site. The zones are defined as follows:

3) **Aquatic Resource Zones –** The Skykomish River and Levee and the former Maloney Creek channel (and associated wetland) are considered Aquatic Resource Zones due to the potential for ecological and recreational exposures, the presence of contaminated groundwater that affects sediment and surface water, and the lack of potential future development, such as housing. The Aquatic Resource Zones are noted in the orange hatching on Figure 6-1.

4) **Developed Zones –** The Developed Zones have been or are likely to be developed for residences, commercial buildings, streets, and public institutions, such as the school, city hall, and community center. These zones are primarily affected by petroleum contaminants in the groundwater and surrounding subsurface soil.

   Three Developed Zones were defined based on location and the different types of petroleum affecting the zones: the Northwest (NW) Developed Zone, the South Developed Zone, and the NE (NE) Developed Zone (Figure 6-1). The NW Developed Zone and the South Developed Zone are affected by petroleum plumes that consist of a mixture of diesel and bunker C and are separated by the Railyard Zone. These two developed zones are noted in the pink hatching pattern on Figure 6-1. The NE Developed Zone is affected by a petroleum plume primarily composed of diesel fuel. Smear zone soil data from 1B-W-1, 1C-W-1, and 2A-W-6 indicate that 85% to 90% of the petroleum present in this Zone is in the diesel range. The greater diesel content in the NE Developed Zone indicates that petroleum in this Zone is more soluble and more biodegradable than the petroleum present in the NW and South Developed Zones. Therefore, different cleanup technologies may be applied to the NE Developed Zone than the NW and South Developed Zones. The NE Developed Zone is noted in purple hatching on Figure 6-1.

5) **Railyard Zone –** The Railyard Zone has historically been used for industrial purposes and should continue as an industrial site for the foreseeable future. It includes BNSF property with surface and subsurface soil impacts. It also includes small areas immediately adjacent to the BNSF property: two with surface soil metal

impacts, and one with surface and subsurface soil TPH impacts. The Railyard Zone is noted in blue hatching on Figure 6-1.

Figure 6-1 provides a clear representation of the locations of these zones. Figure 6-2 illustrates the basis for the areal extent of these zones by overlaying all known and suspected areas of soil, groundwater, and sediment impacts. The extent of TPH soil impacts illustrated on Figure 6-2 is based on the 2,000 mg/kg TPH-diesel contour for surface, vadose, and smear zone soil impacts. This contour was used to represent the maximum extent of impacts exceeding cleanup levels for purposes of the FS/EIS as it closely approximates the areas that exceed the direct contact cleanup level for all TPH.

6.3.2 Points of Compliance

Section 5.3 presents the standard and conditional POCs used to develop and evaluate the remedial alternatives. The POCs are the locations where cleanup levels would be achieved and are considered part of the cleanup standards and are summarized in Table 6-2. Site-wide remedial alternatives were developed to meet cleanup standards for the following three POCs: (1) off-property, conditional groundwater POC at the points of discharge to surface water (SW1 to SW4); (2) on-property, conditional groundwater POC at the property boundary (PB1 to PB4); and (3) the standard POCs (STD).

6.3.3 Remediation Levels

Remediation levels were developed that incorporate physical properties (e.g., free product), chemical concentrations, and exposure pathways. Remediation levels are not cleanup standards, but are used to define where and when individual cleanup technologies will be applied as part of the overall remedial alternative. Specifically, the following remediation levels were integrated into the analysis of remedial alternatives:

1) Provide additional protectiveness to people by achieving direct contact cleanup levels for soil (described in Section 5.2.1) in the upper 2 feet in the Railyard Zone, minimizing contaminated dust and incidental ingestion or inhalation.

2) Provide additional protectiveness to people by achieving direct contact cleanup levels for soil (described in Section 5.2.1) in the upper 4 feet in the NW Developed Zone, preventing incidental ingestion or inhalation at residences and on public property (i.e., the school or community center).

3) Protect people and environmental receptors by achieving cleanup levels in sediment (described in Section 5.2.3) in the former

Maloney Creek channel and the Skykomish River in a manner that will not significantly impact habitat in the wetlands or along the shoreline.

4) Restore groundwater and protect the Skykomish River and former Maloney Creek channel by removing free product.

5) Restore groundwater and protect the Skykomish River and former Maloney Creek channel by removing soil necessary to restore groundwater to drinking water quality (empirical data indicate that only free product in off-railyard areas exceeds 477 µg/L TPH as a sum of EPH/VPH; see Figure 3-9).

6.4 Description of Remedial Alternatives

The approach outlined in Section 6.3 is used in this section to develop a suite of remedial alternatives. Individual cleanup technologies were first selected for each cleanup zone based on the nature and extent of contamination, land use and exposure pathways. The technologies selected for each cleanup zone are described in Section 6.4.1.6. Institutional controls are applicable to some extent in all cleanup zones; therefore, they are discussed in context of all cleanup zones in Section 6.4.1.7.

After grouping technologies by cleanup zone, they were grouped based on their ability to comply with cleanup standards and attain remediation levels. As described in Section 5, compliance with cleanup standards includes attaining the cleanup levels at specific POCs. Soil, sediment and surface water POCs are the same for all alternatives. However, the standard and two conditional POCs for groundwater (defined in Section 5.3) were used to develop the remedial alternatives. The groundwater POCs were used to name the alternatives in Section 6.4.2.

In addition to meeting cleanup levels at the POCs, alternatives were selected based on achieving remediation levels (Table 6-3). Remediation levels mostly apply to soil and sediment cleanup; however, a remediation level for free product removal from groundwater is also included. All alternatives meet the remediation levels, as explained in Section 6.4.2, in addition to meeting the cleanup levels at the POCs.

6.4.1 Detailed Description of Remedial Approaches by Cleanup Zone

The site-wide remedial alternatives presented in Section 6.4.2 use different combinations of cleanup technologies within each cleanup zone, as illustrated in Table 6-4. To limit repetitious text, all cleanup technologies applicable to each cleanup zone are described separately, by cleanup zone, in the following six subsections (as listed on Table 6.4).

For example, the technologies for cleaning up the South Developed Zone include natural attenuation and excavating free product and TPH in the surface soil and the smear zone. Some site-wide remedial alternatives use all of these technologies; whereas, others use only a few of the technologies (Table 6-4). The following six subsections demonstrate how each cleanup technology would be implemented in each cleanup zone and describe all remedial approaches. Section 6.4.2 describes how the remedial alternatives combine these different cleanup technologies in a way that meets site-wide cleanup standards and remediation levels.

6.4.1.1 Levee and Skykomish River Aquatic Resource Zone

This zone incorporates the area downgradient of the existing barrier wall and the locations of petroleum impacts to the bank and sediment of the Skykomish River. The majority of this zone includes the floodwater control levee that was designed by the USACE in 1951 and is currently managed by the King County Department of Natural Resources, Rivers Section.

The cleanup technologies for this zone include:

- Removing surface sediment
- Enhanced bioremediation
- Permeation grouting
- Ozone sparging
- *In situ* flushing
- Excavation

These technologies are described in the following subsections. All activities on the levee would be coordinated with King County, which manages the levee for purposes of local water control.

Remove Surface Sediment

This technology involves the excavation of the upper 4 inches (10 centimeters) of sediment to achieve cleanup levels in the biologically active zone. It is estimated that an area about 440 feet long and 20 feet wide exceeds the cleanup level (Figure 6-3). Including overexcavation to a depth of 1 foot, 330 cubic yards (cy) of sediment is expected to be removed. Surface sediment removal would not occur until soil and groundwater impacts within the levee have been addressed. Sediment removal activities would be designed to comply with ARARs, such as Ecology's water quality standards (including anti-degradation) and the Federal Clean Water Act and Engendered Species Act.

Two of the site-wide remedial alternatives (SW3 and PB2) include excavation of free product from within the levee. For these alternatives, removal of surface sediment would be limited to the free product seep areas since this is where bioassay failures occurred. These alternatives minimize disruption to the shoreline habitat. This sediment removal area is about half the area that exceeds cleanup levels for an excavation volume of 165 cy.

A temporary cofferdam or deflector will be placed in the river to keep surface water away from the sediment excavation. An access ramp to allow dam placement and excavation will be created by removing about 6 feet of clean fill from the top of the levee in a 50-foot-wide area near the east end of the levee. Excavation would be performed using a track-mounted excavator. Difficulties are to be expected due to the presence of cobbles and boulders. Excavated sediment will be immediately removed from the river channel via an off-road dump truck to a stockpile area on the railyard. The excavation will be backfilled with coarse-grained soil, similar to what was excavated. This work would be performed in late summer during low water conditions to minimize impacts on water and protected fish species. The construction window for the South Fork of the Skykomish River and its tributaries between Sunset Falls and Alpine Falls would allow in-water cleanup activities to occur between July 1st and August 31st (WDFW, pers. comm., 2003c). This construction window may be extended based on site-specific permitting.

Enhanced Bioremediation

Enhanced bioremediation is not an effective cleanup technology by itself in the Levee Zone due to the presence of bunker C/diesel free product and significant soil impacts. The purpose of this technology is to address dissolved-phase groundwater impacts that could continue to migrate through the levee under some of the site-wide alternatives due to the presence of free product or significant soil impacts in the Levee Zone or the NW Developed Zone.

Enhanced bioremediation will be implemented using air-sparging techniques. A single row of air sparging wells will be installed across the area that exceeds the groundwater cleanup level of 0.5 mg/L. These wells will be installed through the top of the levee and, as a result, will require that the levee be cleared of brush and trees (Figure 6-4). Aboveground power lines along West River Road will be shielded, as necessary, during drilling and trenching activities. Where this technique is used following ozone sparging (described below), some existing wells might be converted from ozone to air sparging. Wells will be installed at 25-foot spacing, with the top of the well screen 10 feet below the low water table elevation, and air will be injected at a rate of 2 to 3 standard cubic feet per minute (scfm) per well. Compressed air will be supplied using positive displacement blowers located in the vicinity of the levee. These blowers will be contained in insulated sound enclosures to reduce noise impacts. Compressed air piping will be placed in a trench on top of the levee.

Permeation Grouting

This technology would be used to solidify free product in the Levee Zone. The technology involves installing wells on 3- to 20-foot centers and injecting Portland cement to turn the free product and associated soil into a solidified mass. This technology would eliminate seeps to the Skykomish River and prevent leaching of contaminants to groundwater.

The installation of grouting wells will require angle boring from the top of the levee at angles of up to 40 degrees from vertical using a track-mounted ODEX drill rig. Some drilling may also have to occur on West River Road or along the bank of the Skykomish River to get full coverage. Aboveground power lines along West River Road will be shielded, as necessary, during drilling and trenching activities. A 1- to 3-inch PVC grout injection tube with radial drilled holes is used to inject the grout under pressure. This work would be performed during low waters so that grout seeps to the River can be controlled. No aboveground structures or activities remain after permeation grouting.

Ozone Sparging

Ozone sparging is intended to chemically oxidize organic compounds in soil and groundwater. This technology is more typically used to address chlorinated solvents and PAHs because bioremediation is more cost-effective for TPH than ozonation. However, due to the proximity of the levee to ecological receptors, the TPH concentration in the levee, and the heavy petroleum composition, it is believed that ozone sparging might be effective in the Levee Zone. Bench-scale testing is being performed to verify the effectiveness of ozone at degrading the bunker C/diesel impacts identified at the site. At full-scale, this technology requires three rows of ozone sparging wells installed parallel to the river in the levee to provide complete coverage where free product is present, where significant residual soil impacts are present, and where groundwater concentrations exceed 1 mg/L (Figure 6-5). The installation of three rows of wells will require angle boring from the top of the levee at angles of up to 40 degrees from vertical using a track-mounted ODEX drill rig (Figure 6-6). One row of ozone wells will be installed parallel to the river where lower residual soil concentrations are present and where groundwater concentrations are between 0.5 and 1 mg/L. Wells will be installed at 25-foot spacing in each row with the top of the well screen located 10 feet below the low water table elevation. Aboveground power lines along West River Road will be shielded, as necessary, during drilling and trenching activities.

Ozone must be generated near the injection site as it naturally degrades rapidly. Ozone and oxygen generators will be installed at the levee to allow ozone production at concentrations of up to 12 percent in air. This equipment will be contained in insulated sound enclosures to reduce noise impacts. Compressed air piping will be placed in a trench on top of the levee.

In Situ Flushing

In situ flushing is an enhanced groundwater extraction and treatment system that uses a combination of heat, polymers, and surfactants to remove free product and residual soil impacts. Due to the proximity of the levee to surface water, this technology has to be carefully designed to prevent discharges to the river. As a result, injection and extraction will occur in the center of the levee to maximize the likelihood of full containment (Figure 6-7). Injection will occur in the vadose zone using a shallow trench (approximately 560 feet long) at a total rate of 44 gallons per minute (gpm). Because injection will occur in the vadose zone, only surfactants will be used because polymer will increase the injection solution viscosity and hinder infiltration. Extraction will occur to provide capture throughout the levee from a single row of wells. These wells will be screened to 15 feet below the low water elevation, will be spaced evenly every 40 feet, and will extract 4 gpm per well for a total extraction rate of 60 gpm. Aboveground power lines along West River Road will be shielded, as necessary, during drilling and trenching activities.

Unlike other site locations, flushing will be performed in the levee during low rather than high water conditions to minimize the potential for discharges to the river. The water conditioning (heating and mixing) system will be located on the railyard as will the water treatment system. Extracted and treated water will be recycled to the maximum extent possible. These systems will be connected to the levee wells by piping and trenches placed in public rights-of-way. Injection pipes will be insulated to minimize heat loss.

Excavation

Excavation includes the removal of all free product or all contaminated soil from between the existing barrier wall and surface sediment in the Skykomish River (Figure 6-8). All brush on the levee will be removed prior to excavation. A temporary cofferdam or deflector will be placed in the river to keep soil and contamination away from surface water. Power poles and lines along West River Road and the levee will be temporarily relocated during construction activities. Access for dam construction and clearing will be created by cutting an entry in the east side of the levee, as described for surface sediment excavation and by creating a ramp on the west end of the levee. A temporary road will have to be constructed west of the schoolyard to allow traffic to circulate and to provide emergency access to residences on the west end of West River Road. The abandoned residence on West River Road (the second residence east of the school yard) could be demolished so that a road might be constructed to connect Railroad Avenue to West River Road. If this is not possible, an alternate means of access to the west end of West River Road will need to be established, or the residents may need to be vacated during excavation activities.

The excavation will start on the east end of the levee, closest to the bridge. Clean soil will be excavated from the top of the levee and placed in trucks for temporary stockpiling on the railyard. Impacted soil will then be loaded into trucks for temporary stockpiling prior to treatment or disposal. As the excavation proceeds to the west, clean overburden soil might be immediately placed as backfill in previously excavated areas.

The free product excavation is estimated to be 3,730 cy, with 2,490 cy requiring treatment or disposal. Excavation to cleanup levels would generate 18,920 cy of soil, with 12,190 cy requiring treatment or disposal (2,000 mg/kg TPH-diesel).

Alternatives SW3, SW4, PB2 and PB3 assume a sloped excavation sidewall that protects the existing barrier wall, leaving some residual TPH impacts immediately downgradient of the barrier wall. For site-wide alternatives PB4 and STD, the barrier would be excavated since excavation of free and residual product would occur in both the Levee and NW Developed Zones.

Excavation would be performed in late summer during low water conditions to prevent discharges to surface water and to satisfy the "fish window" that is intended to protect threatened species. The "fish window" for the South Fork of the Skykomish River and its tributaries between Sunset Falls and Alpine Falls is July 1st through September 15th. It is assumed that some water in the excavation will be managed to remove any free product that accumulates and to allow collection of excavation verification samples from the bottom of the excavation. Soil confirmation sample analysis will be performed with an on-site laboratory or using 48-hour turnaround at a fixed facility.

6.4.1.2 Former Maloney Creek Aquatic Resource Zone

This zone includes the ditch and wetland areas located north of the Old Cascade Highway and is associated with storm drainage through the former Maloney Creek channel. The zone also includes any surface sediment impacted areas between the culvert and Maloney Creek on the south side of the Old Cascade Highway. This zone is considered separately due to the potential for groundwater discharge to surface water during high water events and due to the presence of a wetland. In addition, coho salmon, a threatened species, have been noted in this storm water drainage. Cleanup in this zone will be closely coordinated with cleanup in the South Developed Zone and on the southern edge of the Railyard Zone.

The cleanup technologies for this zone include:

- Remove surface sediment
- Natural attenuation
- Enhanced bioremediation
- Excavation

These technologies are described in the following subsections.

Remove Surface Sediment

The technology involves the excavation of the upper 4 inches (10 centimeters) of sediment to achieve cleanup levels in the biologically active zone. It is estimated that the full wetland area exceeds the sediment cleanup level including a small area on the downgradient side of the culvert (Figure 6-9). Assuming an excavation depth of 1 foot with over excavation, a total of 1,740 cy of sediment will be removed if excavation is to cleanup levels. A temporary cofferdam or deflector will be placed in the channel to keep soil and contamination away from surface water. Work will be performed in the summer to minimize the likelihood of precipitation. A bypass pump and hose will be used to pump any collected surface water around the excavation area.

Due to the high value of forested wetland, including the presence of mature trees, excavation of all impacted surface sediment would cause significant damage to the habitat. As a result, several alternatives have been developed that include removal of some surface sediment in strategic locations. For these alternatives, the excavation volume is assumed to be one half of the total removal volume or approximately 870 cy. For other alternatives, no excavation of surface sediment is proposed in this zone to avoid impacting the habitat.

Natural Attenuation

Natural attenuation might be used as the primary petroleum treatment method in the Former Maloney Creek Aquatic Zone due to the presence of the wetland habitat and petroleum constituents at moderate concentrations (per Figure 3-11, only boring 2B-SD-5 has NWTPH-Dx concentrations above 3,200 mg/kg). Free product present on the adjacent South Developed Zone at MW-39 would be removed to accelerate natural attenuation. Natural attenuation will be monitored using compliance monitoring data. Dissolved oxygen data will also be collected because aerobic degradation is anticipated to be the primary method of petroleum degradation.

Enhanced Bioremediation

Enhanced bioremediation is a viable *in situ* cleanup alternative for the Former Maloney Creek Aquatic Zone, and it will minimize adverse impacts on wetland and aquatic habitats. Due to the presence of mixed bunker C/diesel free product this technology will remove 50 to 80 percent of the petroleum impacts. This might be sufficient to meet cleanup standards because bioremediation will target the more soluble and toxic components of TPH, and soil TPH concentrations in the smear zone do not significantly exceed cleanup levels.

Enhanced bioremediation will be implemented using air sparging techniques. Air sparging wells will be installed across the area that exceeds the soil direct contact cleanup level in the smear zone. These wells will be installed to completely cover this area, as illustrated in Figure 6-10. Wells will be installed at 25-foot spacing, with the top of the well screen 10 feet below the low water table elevation. Air will be injected at a rate of 2 to 3 scfm per well. Some wells might need to be angle-bored to minimize impacts to the wetland. The adverse impacts of drilling and operating wells in the wetland will be less significant (both in intensity and duration) than the impacts of excavating in the wetland.

Air bubbling up through the wetland represents a less negative impact to the habitat than excavation of surface sediment or soil. Compressed air will be supplied using positive displacement blowers located on the railyard in the vicinity of the former Maloney Creek channel. The blowers will be contained in insulated sound enclosures to reduce noise impacts. Compressed air piping will be placed in trenches to the maximum extent possible; however, in order to minimize impact to the wetland habit, much of the piping might be completed aboveground.

Excavation

Excavation includes the complete removal of all soil exceeding cleanup levels from the zone, including surface sediment in the former Maloney Creek channel and the wetland areas (Figure 6-11). All brush and trees will be removed prior to excavation. A temporary dam will be placed in the channel to keep surface water away from the excavation and work will be performed in the summer to minimize the likelihood of precipitation. A bypass pump and hose will be used to pump any collected surface water around the excavation area. Disturbance of the wetland area will require mitigation by creating equal or higher value wetlands. This mitigation will occur at the existing wetland and possibly at another, as-yet undetermined location within the Maloney Creek watershed.

Impacted surface sediment will be removed first. Any clean soil between the surface impacts and the smear zone will be excavated and placed in trucks for temporary stockpiling on the railyard. Impacted soil will then be loaded into trucks for temporary stockpiling prior to treatment or disposal. As the excavation proceeds, clean soil will be used as backfill in previously excavated areas. The total excavation volume is estimated to be 7,880 cy, with 7,260 cy requiring treatment or disposal. These volumes were estimated based on the 2,000 mg/kg TPH-diesel cleanup level.

The estimated maximum depth of excavation is 12 feet. Excavation will include sloping sidewalls. Some excavation water will be managed to remove any free product that accumulates and to allow collection of excavation verification samples from the bottom of the excavation. Soil analysis will be performed with an on-site laboratory or using 48-hour turnaround at a fixed facility.

6.4.1.3 Northeast Developed Zone

The NE Developed Zone has been developed for residences, commercial buildings, streets, and institutions such as city hall. The NE Developed Zone is affected by a petroleum plume in smear zone soil and groundwater that is primarily composed of diesel fuel, generally greater than 75 percent. This petroleum is less viscous, more soluble, and more biodegradable than the petroleum present in the NW and South Developed Zones. An oil column was historically located in the vicinity of MW-21 where free product is present indicating that bunker C might be present in the immediate vicinity of MW-21 although there are no soil data to confirm this. Otherwise, the majority of the impacts appear to be associated with diesel fueling activities that occurred about 150 feet to the south of MW-21.

Cleanup technologies for this zone include:

- Natural attenuation
- Enhanced bioremediation
- Excavation

These technologies are described in the following subsections.

Natural Attenuation

Natural attenuation in the NE Developed Zone has the potential to significantly reduce soil and groundwater concentrations due to the high percentage of diesel. Diesel-range hydrocarbons are soluble and biodegradable and would be expected to attenuate in a reasonable timeframe. Soil direct contact criteria are only exceeded in a small area and groundwater currently appears to attenuate to cleanup levels prior to discharging to the Skykomish River. Natural attenuation will be monitored using compliance monitoring data. Dissolved oxygen data will also be collected because aerobic degradation is anticipated to be the primary method of petroleum degradation.

Enhanced Bioremediation

Enhanced bioremediation is considered a viable alternative for the NE Developed Zone because the primary petroleum constituent is diesel. Enhanced bioremediation has been implemented at multiple sites to achieve groundwater cleanup levels where thin accumulations (less than 2 feet) of diesel free product have been present. This is likely due to both the solubility and biodegradability of diesel constituents. RETEC's database of bench-scale testing data (Appendix J) indicates that soil concentrations of diesel are reduced, on average, by 90% due to the application of enhanced bioremediation techniques.

Air sparging wells will be installed across the area that exceeds the soil direct contact cleanup level in the smear zone and the groundwater cleanup level. Air sparging wells will be installed to completely cover the area of free product when free product is not flushed or excavated, as illustrated in Figure 6-12. Otherwise, a single row of air sparging wells will be used in this area. One or two additional rows of sparging wells will intersect the groundwater plume downgradient to the north depending on the desired restoration timeframe and accessibility of public and private property. The locations of air sparging rows have been selected to avoid generating vapors that could cause nuisance odors beneath inhabited structures; vapor extraction will be included as a contingency should nuisance odors become a problem.

Wells will be installed at 25-foot spacing in each row, with the top of the well screen 10 feet below the low water table elevation. Air will be injected at a rate of 2 to 3 scfm per well. Compressed air will be supplied using positive displacement blowers located on the railyard near the depot. The blowers will be contained in insulated sound enclosures to reduce noise impacts. Compressed air piping will be placed in trenches located on BNSF property and public right-of-ways.

Excavation

Excavation includes either the removal of free product or the removal of all free product and all soil exceeding cleanup levels (2,000 mg/kg TPH) (Figure 6-13). For the free product-only excavation approach, the objective would be to excavate as much free product as possible without significantly impacting roads or utilities. This would limit the excavation to between Railroad Avenue and the BNSF property boundary in the vicinity of MW-21.

Two or three residences will need to be temporarily relocated to excavate all free product and contaminated soil in this zone. Use of shoring might be necessary to protect some structures. Utilities are also present, including a telephone switching station and associated fiber optics cables. A 2-inch water line is present on both Railroad Avenue and 3rd Street. Overhead power is present on the north side of Railroad Avenue and will need to be moved during excavation. All utilities will need to be protected or temporarily rerouted to facilitate excavation. A bypass road will be necessary to maintain access to residences east along Railroad Avenue.

Site clearing includes removal of asphalt paving, landscaping (including some large trees), and relocation or demolition of the residences. A significant thickness of clean soil exists in the vadose zone that will be excavated and stockpiled adjacent to the excavation area. Impacted soil will be loaded into trucks for temporary stockpiling prior to treatment or disposal. The total soil excavation volume for accessible free product is estimated to be 4,861 cy, with 2,455 cy requiring treatment or disposal. The soil excavation volume for all soil exceeding cleanup levels is estimated to be 22,873 cy with 11,054 cy requiring treatment or disposal. The estimated maximum depth of excavation is 17 feet.

6.4.1.4 South Developed Zone

The South Developed Zone affects two residences and involves petroleum in surface soil, smear zone soil and groundwater that is composed of mixed bunker C and diesel. These impacts appear to be limited in extent. Free product present in MW-39 is more viscous than free product noted elsewhere on the site and appears to be coincident with a previous channel of Maloney Creek that may have been affected by railyard operations. Cleanup of this zone will have to be closely coordinated with cleanup of the Former Maloney Creek Aquatic Zone.

The cleanup technologies for this zone include:

- Natural attenuation
- Excavation

These technologies are described in the following subsections.

Natural Attenuation

Natural attenuation in the South Developed Zone would only be used following free product excavation. The high viscosity of the product in MW-39 suggests that limited residual impacts will remain after free product removal. In addition, the free product appears to be associated with an earlier channel of Maloney Creek that is now backfilled. As a result, the impacts are suspected to be limited to this earlier channel and complete removal of this limited area may be possible. Natural attenuation will be monitored using compliance monitoring data. Dissolved oxygen data will also be collected because aerobic degradation is anticipated to be the primary method of petroleum degradation.

Excavation

Due to the limited extent of impacts and the viscous nature of the free product, excavation is considered a very viable cleanup technology for this zone. The approach to excavation might have to be altered based on the cleanup technology used at the Former Maloney Creek Aquatic Zone.

Excavation includes either free product excavation or the complete removal of all free product and soil exceeding cleanup levels (2,000 mg/kg TPH as diesel) (Figure 6-14). Little to no clearing will be necessary for free product excavation, as it is primarily located in a grass area. The garage associated with one residence might need to be temporarily relocated or demolished and reconstructed to facilitate soil excavation. Utilities affected include services to the residences. All utilities will be temporarily disconnected or rerouted, as necessary.

A limited thickness of clean soil exists in the vadose zone that will be excavated and stockpiled adjacent to the excavation area. Impacted soil will be loaded into trucks for temporary stockpiling prior to treatment or disposal. The soil volume for excavating free product is estimated to be 336 cy, with 265 cy requiring treatment or disposal. The soil volume for excavating all contaminated soil is 1,979 cy, with 1,546 cy requiring treatment or disposal.

6.4.1.5 Northwest Developed Zone

The NW Developed Zone has multiple residences, commercial buildings, streets, and institutions such as the school and community center. The zone is primarily affected by petroleum contaminants in the smear zone soil and groundwater and the petroleum consists of a mixture of diesel and bunker C. This is the largest and most developed zone at the site and includes several large or historic (Washington Heritage Register and National Register of Historic Places) structures, such as Maloney’s General Store, the Skykomish Hotel and the School. This zone also has a very shallow smear zone that extends to within about 2 feet of ground surface in some areas, is very close to the levee and the Skykomish River.

Free product is present in this zone as two narrow bands between the railyard and the levee. The petroleum appears to originate in the vicinity of the former oil sump that was used to transfer bunker C from railcars to the aboveground 100,000 gallon oil storage tank on a 30-foot steel tower. This interpretation is based on free product thickness measurements, the location of oil seeps to the river, soil and groundwater data, known or suspected petroleum sources, and lithologic controls.

Interim actions have been performed in the NW Developed Zone that include (1) installation of free product skimming wells in 1996; (2) construction of a free product barrier wall in 2001; and (3) installation of new skimming wells and pumps, and upgrades to existing wells and pumps in 2002. These systems are effectively containing and capturing free product at the downgradient boundary of the NW Developed Zone and preventing migration from this zone into the levee and the Skykomish River, as evidenced by monitoring data from wells located at the ends of the barrier wall and product recovery.

In addition to these existing, interim measures, the cleanup technologies for this zone include:

- Surface soil excavation
- Natural attenuation
- Free product recovery trenches
- Enhanced bioremediation
- *In situ* flushing
- Excavation

These technologies are described in the following subsections.

Surface Soil Excavation

Lead-contaminated soil (250 mg/kg) was noted at seven sample locations within the NW Developed Zone (Figure 6-15). The locations are isolated and are not contiguous with the railyard. The source(s) of this lead is unknown (RETEC, 2002a). The lead soil exists in yards near residential or commercial properties and in the schoolyard. Because the source and distribution of the lead in soil is unknown, estimating excavation volume is difficult. Assuming 2-foot-deep excavations, 400 cy of soil will be excavated from throughout town using a backhoe. The excavated soil will be placed in trucks and transported to stockpiles on the railyard. The soil will be shipped to an off-site landfill by truck or rail. These areas will be backfilled and restored to pre-excavation conditions. Given the shallow excavation, no significant impacts to utilities or structures are expected.

Natural Attenuation

Natural attenuation in the NW Developed Zone would only be effective following free product removal. Once the free product is removed, natural attenuation will help address the residual soil and groundwater impacts. In each case where residual impacts remain in the NW Developed Zone, enhanced bioremediation will be implemented in the Levee Zone to protect people and animals that use the Skykomish River. Natural attenuation will address groundwater concentrations in the NW Developed Zone in the long term. Natural attenuation will be monitored using compliance monitoring data. Dissolved oxygen data will also be collected because aerobic degradation is anticipated to be the primary method of petroleum degradation.

Free Product Recovery Trenches

Recovery trenches provide a minimally intrusive means to remove free product from the subsurface. The use of trenches relies on the hydraulic gradient to transport free product to the trenches. Trenches would be excavated using bioslurry techniques to 5 feet below the low water table. The trench backfill material would be designed to be compatible with native soil conditions and an impermeable barrier would be placed on the downgradient wall of the trench to prevent free product from escaping beyond the trench. Sumps will be placed in the trench at about 50-foot spacing.

Proposed locations of recovery trenches are illustrated in Figure 6-16. Excavation of these trenches will require work on public and private property and associated removal of pavement, landscaping or other features. Berms will be constructed around the trenching area to prevent loss of bioslurry overflows. Temporary mixing equipment, tanks, and pumps will be required near the excavation areas to supply bioslurry. Trench backfill material, impermeable barrier material, and sump material will also be stockpiled near the work area. Excavated material will be transported to the railyard for stockpiling prior to off-site shipment for disposal via rail or truck. The work surfaces will be replaced to pre-trenching conditions.

Electrically-driven skimmer pumps will be placed in vaults at each sump location and an electric control panel will be located nearby. No other aboveground features will be present. The skimming pumps will likely remain in operation for at least 10 years and may need to remain in operation for over 30 years.

Enhanced Bioremediation

Enhanced bioremediation is not an effective cleanup technology by itself in the NW Developed Zone, due to the presence of bunker C/diesel free product and significant soil impacts. This technology would only be used once the free product has been addressed by excavation or flushing. The purpose of this technology is to address residual soil and groundwater impacts to the maximum extent practicable.

Enhanced bioremediation will be implemented using air sparging techniques. Air sparging introduces oxygen to the soil and groundwater to stimulate aerobic biodegradation in the vicinity of the air sparge wells and to other areas as the oxygenated groundwater migrates downgradient. Multiple rows of air sparging wells will be installed across the zone (Figure 6-17). These wells will be installed on public and private property. The locations of the sparging wells have been selected to minimize nuisance odors near inhabited structures; vapor extraction will be retained as a contingency to address these odors should they become a concern. Wells will be installed at 25-foot spacing, with the top of the well screen 10 feet below the low water table elevation.

Air will be injected at a rate of 2 to 3 scfm per well. Compressed air will be supplied using positive displacement blowers located on the railyard. These blowers will be contained in insulated sound enclosures to reduce noise impacts. Compressed air piping will be placed in trenches to connect the equipment on the railyard with the air sparging wells.

All work surfaces will be replaced to pre-cleanup conditions. A flush-with-grade monument will be present at each wellhead. All other equipment and activities will occur on the railyard.

In Situ Flushing

In situ flushing might be used in conjunction with excavation to remove free and residual product for a number of alternatives. *In situ* flushing is an enhanced groundwater extraction and treatment system that uses a combination of heat, polymers, and surfactants to remove free product and residual soil impacts. Flushing will be performed during high water conditions to allow for removal of free or residual product from the top of the smear zone. Flushing is only considered for limited-access areas (e.g., under bridges) since it is not a proven technology at full scale for the type of contaminants at this site, and there is no established treatment method for reuse of extracted groundwater or discharge of treated water to the River.

To simplify the layout of flushing systems, two standard flushing units were created assuming 40-foot spacing between injection and extraction wells within a row and 80-foot spacing between rows of wells. These units are 90 gpm (3 injection and 3 extraction wells) and 60 gpm (2 injection and 2 extraction wells) in size with equal injection and extractions rates. All wells will be screened to 15 feet below the water table. Each unit will operate for a period of about 6 months in order to exchange 10 pore volumes of water. Figure 6-18 illustrates how these units could be combined with excavation to provide removal of free product or both free and residual product. For free product, the system includes three 90-gpm units and eight 60-gpm units for a total flow rate of 750 gpm. For both free and residual product, the system includes nine 90-gpm units and seven 60-gpm units for a total flow rate of 1,230 gpm. A non-standard system would need to be designed to address residual product beneath the school. These flushing units would likely be implemented in phases to control the size of the equipment required.

The water conditioning (heating and mixing) system will be located on the railyard as will the water treatment system. Extracted and treated water will be recycled to the maximum amount possible. These systems will be connected to the wells by piping and trenches placed on the railyard and on public and private property. Injection pipes will be insulated to minimize heat loss. Trench areas will be backfilled and replaced to pre-cleanup conditions.

Horizontal boring may be required underneath railroad tracks to connect the wells to the treatment and conditioning system.

Excavation

Excavation in the NW Developed Zone includes one of the following (Figure 6-19):

1) Excavation to remove free product, where accessible
2) Excavation to remove all free product
3) Excavation of shallow smear zone impacts
4) Excavation to remove both free and residual product
5) Complete excavation of all free product areas and all soil exceeding cleanup levels.

These five scenarios are discussed individually below; however, all excavation work would occur during low water conditions to maximize access to impacted smear zone soil. Clean overburden soil will be stockpiled as close to the excavation as possible and will be used as clean backfill. Impacted soil will be hauled to the railyard and stockpiled for on-site treatment or hauling to an off-site landfill via rail or truck. All utilities will need to be protected or temporarily rerouted to facilitate excavation. Various bypass roads will be necessary during excavation to maintain access to residences, businesses and public facilities. Site clearing includes removal of asphalt paving, landscaping (including some large trees), and relocation or demolition of several structures.

- **Excavation to remove free product, where accessible**. Excavation to remove free product, where accessible, is intended to minimize disruption to the community while removing a significant amount of free product. The long-term environmental benefit of this approach is questionable due to the patchwork of excavation that will occur (Figure 6-19). Accessibility is generally defined as anywhere a building is not present. As a result, excavation will still disrupt traffic and utilities. For the purpose of the FS/EIS, it is assumed that excavations will be sloped up to the sides of buildings that remain. Based on this approach, approximately 32,373 cy of soil will be excavated with 21,778 cy requiring treatment or disposal. All grades and surfaces will be replaced to pre-excavation conditions. This approach can be used in conjunction with *in-situ* flushing to remove all free product from the NW Developed Zone over an extended period of time, but without the need to move structures.

- **Excavation to remove all free product**. Excavation to remove all free product will require the temporary relocation and replacement or demolition and reconstruction of about eight structures and temporary structural support to allow excavation underneath several other structures (Figure 6-19). These structures include private residences, the hotel, the depot, the post office, the stove shop, the community center, and the teacher's cottage. Based on this approach, approximately 38,066 cy of soil will be excavated with 20,966 cy requiring treatment or disposal. All grades and surfaces will be replaced to pre-excavation conditions.

- **Excavation of shallow smear zone impacts**. Excavation of shallow smear zone impacts is intended to remove contaminated soil to a depth of 4 feet bgs in accessible areas (those areas not already covered by a structure). Cleanup to this depth will enable routine work in residential yards and public utility work without future exposure to contaminated soil. This work will disrupt traffic and utilities, but could be phased to allow residents to remain in their homes. Based on this approach, approximately 14,880 cy of soil will be excavated with 7,440 cy requiring treatment or disposal. All grades and surfaces will be replaced to pre-excavation conditions.

- **Excavation to remove all free and residual product, and excavation to remove all soil above cleanup levels**. Both of these scenarios require the temporary relocation and replacement or demolition and reconstruction of about 18 structures and temporary structural support to allow excavation underneath several other structures (Figure 6-19). The structures affected by these excavations would include private residences, the hotel, the depot, the post office, the stove shop, the community center, the teacher's cottage, the school and portions of the motel. Based on the excavation of al1 free and residual product, approximately 111,392 cy of soil will be excavated with 68,952 cy requiring treatment or disposal. Based on the excavation of all soil exceeding cleanup levels, approximately 136,417 cy of soil will be excavated with 83,739 cy requiring treatment or disposal. All grades and surfaces will be replaced to pre-excavation conditions and all structures will be replaced or rebuilt.

6.4.1.6 Railyard

The Railyard Zone has historically been used for industrial purposes and will continue as an industrial site for the foreseeable future. It includes BNSF property with surface and subsurface soil impacts. It also includes small areas immediately adjacent to the BNSF property: two with surface soil metals impacts, and one with surface and subsurface soil TPH impacts. The railyard has an active main line with two sidings and two other active sidings south of the main line area. Both passenger and cargo trains use the main line and sidings; approximately one train per hour passes the site.

All alternatives except one leave the rail lines in place and use *in situ* remedies to address these impacts, due to the expense and disruption associated with moving the main line. One alternative relies on excavation, as it is the only technology currently considered effective enough to result in a permanent removal of all contaminated soil throughout the site. Results of bench-scale testing might indicate that flushing or ozonation could also be effective enough to result in permanent removal on the railyard. Fiber optics, electrical, and signal lines are present within the Railyard Zone. Any crossing of the rail lines will require horizontal boring.

The cleanup technologies for this zone include:

- Excavate surface soil
- Skimming free product
- Free product recovery trenches
- Natural attenuation
- Enhanced bioremediation
- *In situ* flushing
- Excavation

These technologies are described in the following subsections.

Excavate Surface Soil

Lead, arsenic, and TPH exceed the direct-contact cleanup criteria in several locations on the railyard. The impacted areas will be excavated to 2 feet below grade and will be capped with clean soil or ballast to prevent direct contact by site workers and trespassers. Based on the excavation outlines illustrated on Figure 6-20, it is estimated that 5,700 cy are associated with metals and an additional 4,800 cy are associated with TPH. Metals-impacted soil will be excavated in all site-wide alternatives to prevent exposure via dust. Soil exceeding cleanup levels will remain in place across much of the site; dermal contact will be prevented by a protective layer of clean soil (or ballast on the railyard).

Soil will be excavated using a backhoe or excavator. The excavated soil will be placed in trucks and transported to stockpiles on the railyard. The soil will be shipped to an off-site landfill by truck or rail. The excavated area will be lined with a woven-fabric, indicator layer to separate the subsurface-impacted soil from the clean-cap material.

Skimming Free Product

For site-wide alternatives with a conditional groundwater POC at the Skykomish River, aggressive free product removal on the railyard contributes little to no benefit to the protection of human health and the environment although it reduces the restoration time frame for groundwater on the railyard. For other alternatives, installation of skimming wells will remove free product up to the BNSF property boundary (alternative SW1) and at free product plumes within the railyard (alternatives SW2, SW3, SW4, and PB1). These wells will be installed at 50-foot centers at the downgradient edge of the free product plumes. Wells will be installed using standard drilling techniques and the wells will be screened across the range of water table fluctuation. The pumps will be housed in above-ground structures protected by bollards.

Free Product Recovery Trenches

Recovery trenches provide a minimally intrusive means to remove free product from the subsurface. The use of trenches relies on the hydraulic gradient to transport free product to the trenches. Trenches would be excavated using bioslurry techniques to 5 feet below the low water table. The trench backfill material would be designed to be compatible with native soil conditions and an impermeable barrier would be placed on the downgradient wall of the trench to prevent free product from escaping beyond the trench. Sumps will be placed in the trench at about 50-foot spacing.

Proposed locations of recovery trenches are illustrated in Figure 6-21. Due to the location of free product on the railyard, recovery trenches are considered primarily for the downgradient zone/property boundary. Berms will be constructed around the trenching area to prevent loss of bioslurry overflows. Temporary mixing equipment, tanks, and pumps will be required near the excavation area to supply bioslurry. Trench backfill material, impermeable barrier material, and sump material will also be stockpiled near the work area. Excavated material will be stockpiled on the railyard prior to off-site shipment for disposal via rail or truck. The work surfaces will be replaced to pre-trenching conditions.

Electric skimming pumps will be placed in vaults at each sump location and an electric control panel will be located nearby. No other aboveground features will be present. The skimming pumps will likely remain in operation for a period exceeding 10 years.

Natural Attenuation

Natural attenuation in the Railyard Zone would only be used following free product removal. Because of the presence of oil-range petroleum throughout this zone, skimming wells and pumps, recovery trenches, excavation, or flushing will be used to remove the free product prior to relying on natural attenuation. Once the free product is removed, natural attenuation will help address the residual soil and groundwater impacts. Natural attenuation will be effective in this zone due to the distance between the railyard and the primary downgradient ecological receptor, the Skykomish River. Compliance with groundwater cleanup levels at the BNSF property boundary could be accelerated with enhanced bioremediation. Natural attenuation will be monitored using compliance monitoring data. Dissolved oxygen data will also be collected since aerobic degradation is anticipated to be the primary method of petroleum degradation.

Enhanced Bioremediation

Enhanced bioremediation is not an effective cleanup technology by itself in the Railyard Zone due to the presence of bunker C/diesel free product and significant soil impacts. This technology will only be used once the significant impacts have been addressed by recovery trenches, excavation, or flushing. Enhanced bioremediation will be implemented as a groundwater containment remedy using air sparging techniques.

As a containment remedy, enhanced bioremediation will include a single row of air sparging wells located near the downgradient zone/property boundary (Figure 6-22). This row will stretch across the whole area where groundwater exceeds the cleanup level (0.5 mg/L TPH as diesel).

Wells will be installed at 25-foot spacing, with the top of the well screen 10 feet below the low water table elevation, and air will be injected at a rate of 2 to 3 scfm per well. Compressed air will be supplied using positive displacement blowers located on the railyard. These blowers will be contained in insulated sound enclosures to reduce noise impacts. Compressed air piping will be placed in trenches to connect the equipment on the railyard with the air sparging wells.

All work surfaces will be replaced to pre-cleanup conditions. A flush-with-grade monument will be present at each wellhead. All other equipment will be restricted to a small equipment pad.

In Situ Flushing

In situ flushing might be used to remove free product for a number of alternatives (Figure 6-23). *In situ* flushing is an enhanced groundwater extraction and treatment system that uses a combination of heat, polymers, and surfactants to remove free product and residual soil impacts. Flushing will be performed during high water conditions to enable free product removal from the top of the smear zone. Flushing is only considered for limited-access areas (e.g., under active rail lines) since it is not a proven technology at full scale for the type of contaminants at this site, and there is no established treatment method for reuse of excavated water or discharge of treated water to the River.

To simplify the layout of flushing systems, two standard flushing units were created assuming 40-foot spacing between injection and extraction wells within a row and 80-foot spacing between rows of wells. These units are 90 gpm (3 injection and 3 extraction wells) and 60 gpm (2 injection and 2 extraction wells) in size with equal injection and extractions rates. All wells will be screened to 15 feet below the water table. Each unit will operate for a period of about 6 months in order to exchange 10 pore volumes of water. For the free product areas where flushing is being considered, the system includes three 90-gpm units and one 60-gpm unit for a total flow rate of 330 gpm for the two northwest plumes and one 60-gpm unit for the far east plume.

The water conditioning (heating and mixing) system will be located on the railyard as will the water treatment system. Extracted and treated water will be recycled to the maximum amount possible. These systems will be connected to the wells by piping and trenches placed on the railyard and on public and private property. Injection pipes will be insulated to minimize heat loss. Trench areas will be backfilled and replaced to pre-cleanup conditions. Horizontal borings might be required underneath railroad tracks to connect the wells to the treatment and conditioning system.

Excavation

Excavation in the Railyard Zone includes either (1) excavation of free product at the two southern free product plumes, or (2) the complete excavation of all free product areas and all contaminated soil (Figure 6-24). These two scenarios are discussed individually below; however, both scenarios would occur during low water conditions to maximize access to impacted smear zone soil. Clean overburden soil will be stockpiled as close to the excavation as possible and will be used as clean backfill. Impacted soil will be stockpiled on the railyard for on-site treatment or hauling to an off-site landfill via rail or truck. All utilities will need to be protected or temporarily rerouted to facilitate excavation. Little to no site clearing is required on the railyard although excavation of all contaminated soil will require temporary relocation of rail lines.

- **Excavation to Remove Free Product at the Two Southern Plumes.** This scenario is intended to maximize free product removal while avoiding disruption of railyard activities. This scenario will be used in conjunction with flushing to address the inaccessible free product areas. Accessibility is generally defined as anywhere a building or active rail line is not present. For the purpose of the FS/EIS, it is assumed that excavations will be sloped to maintain the stability of surface structure and rail lines. Based on this scenario, approximately 2,634 cy of soil will be excavated with 2,011 cy requiring treatment or disposal. All grades and surfaces will be replaced to pre-excavation conditions.

- **Excavation to Remove All Contaminated Soil**. This scenario is only included in one remedial alternative. The excavation will require the temporary relocation and replacement of active rail lines to provide complete site access for excavation. Based on the excavation of all free and residual product, approximately 24,543 cy of soil will be excavated with 12,682 cy requiring treatment or disposal. Based on the excavation of all soil exceeding cleanup levels, approximately 151,543 cy of soil will be excavated with 80,325 cy requiring treatment or disposal. All grades and surfaces will be replaced to pre-excavation conditions.

6.4.1.7 All Cleanup Zones (Institutional Controls)

Institutional controls are an essential component of any cleanup action. Institutional controls are legal or administrative measures designed to limit or control activities that could result in exposures to contamination before, during and after a cleanup action, particularly if contaminant residues are likely to remain above cleanup levels for an extended period of time. For the Skykomish cleanup, institutional controls would be designed to:

- Ensure access by BNSF or Ecology to remedial systems (e.g., cleanup or monitoring equipment) before, during and after active cleanup operations

- Protect residents and construction workers from exposure to hazardous substances on site during and after active cleanup operations

A common form of institutional control that satisfies these objectives is a Restrictive Covenant that limits or restricts the use of a property. The Covenant is said to “run with the land” as provided by law and is binding on all parties and all persons claiming under them including all current and future owners of any portion of or interest in the property. A Restrictive Covenant for Skykomish properties subject to institutional controls would likely contain:

- A provision prohibiting the removal of groundwater for domestic, agricultural, commercial or industrial purposes

- A requirement that property owners notify and gain the approval of Ecology and BNSF before commencing any work that would require excavating or drilling in areas where hazardous substances are located in the subsurface

- A requirement that the property Owner notify BNSF and Ecology before the Owner conveys any interest in the property, and notify a prospective buyer or tenant of the Restrictive Covenant

- A provision allowing BNSF and Ecology to enter the property at reasonable times and after reasonable notice if necessary to evaluate the cleanup action

- A provision allowing the Owner to remove or modify the Restrictive Covenant with the consent of Ecology

Another common form of institutional control is a local ordinance or a state rule or regulation. Local government, using its general land use authority, can limit the installation of groundwater wells (Skykomish already has such an ordinance) and can require permits before excavation or drilling occurs in contaminated areas. The permit would ensure that any contaminated soil or groundwater be properly managed. Ecology can adopt similar regulations (Ecology already has a rule prohibiting new wells in contaminated zones).

To the extent required by WAC 173-340-440 (11), BNSF will establish financial assurance for cleanup actions that include engineered and/or institutional controls. Financial assurance is intended to demonstrate that BNSF has sufficient resources to pay for costs associated with the operation and maintenance of the cleanup action, including institutional controls, compliance monitoring and corrective measures. BNSF currently provides financial assurance for other cleanup sites using a corporate financial test consistent with EPA requirements (40 CFR Part 264, Subpart F) and comparable state requirements.

6.4.2 Description of Site-Wide Remedial Alternatives

This section provides a summary description of each site-wide remedial alternative. More specific information regarding how each cleanup technology would be implemented in each cleanup zone is described in Section 6.4.1.

Site-wide remedial alternatives were developed to meet cleanup standards for the following three POCs: (1) off-property, conditional groundwater POC at the points of discharge to surface water (SW1 to SW4); (2) on-property, conditional groundwater POC at the property boundary (PB1 to PB4); and (3) the standard POCs (STD). Remedial alternative STD represents the most permanent alternative, and it meets cleanup levels at the standard POCs for all media. A No Action alternative is not presented in the tables but is retained in the text to satisfy SEPA requirements.

Table 6-3 summarizes how the groundwater POCs were combined with soil, sediment, and groundwater cleanup and remediation levels to develop the remedial alternatives. The matrix provides a basis for understanding the alternative development process and comparing the alternatives with respect to compliance with cleanup standards.

All of the alternatives in this FS/EIS (except No Action) can achieve cleanup standards and protect public health and the environment. Thus, the bulk of this document analyses the trade-offs between restoration time frame and degree of permanence (which includes cost), and minimizing adverse impacts to the built and natural environment. A preferred alternative will result from the analysis presented in Section 7 and public and agency comment.

Table 6-4 provides a matrix that illustrates which remedial approaches were selected for each medium in each cleanup zone. Table 6-5 further expands this matrix by providing a summary description of the remedial approach for each zone for each site-wide remedial alternative.

6.4.2.1 Alternatives With the Off-Property, Conditional Groundwater Point of Compliance

The alternatives in this section were developed to meet an off-property, conditional groundwater POC (i.e., groundwater must achieve cleanup levels before discharging to the River or Maloney Creek). The SW alternatives will improve groundwater at the site but will not meet groundwater cleanup levels between BNSF property and the River. Per WAC 173-340-720 (8)(d)(ii), the affected property owners between the railyard and the surface water body must agree in writing to the use of the conditional point of compliance. The alternatives are discussed from left to right on Table 6-5 as you proceed through the discussions below. In general, more aggressive alternatives are more costly than less aggressive alternatives, thereby reducing restoration time and increasing permanence.

Alternative SW1

The cleanup technologies that combine to make up Alternative SW1 are listed on Table 6-5. Together these remedial approaches satisfy the minimum requirements of MTCA by removing free product, satisfying groundwater cleanup standards before reaching points of discharge, and providing containment and institutional controls to prevent dermal contact with soil off the railyard (Figure 6-25). This alternative permanently addresses the higher risk pathways of:

- Groundwater and oil discharges to the Skykomish River

- Contaminated surface soil that might cause dust or be a direct contact concern

This alternative also minimizes short-term impacts to the community and the environment while relying on a long restoration timeframe and institutional controls to achieve cleanup.

Natural attenuation is used in the Former Maloney Creek Aquatic Zone to minimize the potential for habitat damage while attempting to restore soil and groundwater that is moderately impacted by petroleum.

Sediment impacts in the Levee Zone and the former Maloney Creek channel will be addressed by natural recovery to avoid damage to the habitat and to maximize the net environmental benefit of the habitat.

Alternative SW2

The cleanup technologies that combine to make up Alternative SW2 are listed on Table 6-5. Alternative SW2 builds on SW1 by adding the following elements:

- Free product recovery trenches in the NW Developed Zone to supplement the existing barrier wall and skimming system

- More aggressive free product recovery on the railyard by replacing skimming wells with recovery trenches at the property boundary and adding skimming wells to remove free product from the interior of the railyard

A plan view illustrating the SW2 site-wide remedial alternative is provided in Figure 6-26. This alternative provides some additional short-term protectiveness but does not significantly shorten the long restoration time frame.

Alternative SW3

The cleanup technologies that combine to make up Alternative SW3 are listed on Table 6-5. Alternative SW3 provides the following additional actions relative to SW2:

- Excavating or grouting of free product in the levee to reduce the time frame required to eliminate seeps

- Removing impacted surface sediment associated with the free product removal in the levee noted above

- Implementing enhanced bioremediation in the NE Developed Zone to achieve soil and groundwater cleanup levels

- Excavating free product, where accessible, in the NW Developed Zone

A plan view illustrating the SW3 site-wide remedial alternative is provided in Figure 6-27. This alternative provides additional short-term protectiveness in the Levee Aquatic Zone, reduces the time frame to permanently remove free product in the NW Developed Zones, and accelerates groundwater cleanup in the NE Developed Zone.

Alternative SW4

The cleanup technologies that combine to make up Alternative SW4 are listed on Table 6-5. Alternative SW4 is evaluated with a conditional groundwater POC at the River and Maloney Creek. This alternative provides additional cleanup actions as follows:

- Excavating, ozone sparging, or flushing in the levee to a soil remediation level that is protective of groundwater

- Removing all contaminated surface sediment in the Skykomish River

- Removing impacted surface sediment in the former Maloney Creek channel to the extent that it does not significantly damage the wetland

- Implementing enhanced bioremediation in the former Maloney Creek channel to address soil impacts and reduce the potential for recontamination of sediment

- Excavating all soil above cleanup levels from the South Developed Zone

- Excavating or flushing all free product in the NW Developed Zone

- Excavating shallow smear zone impacts in the NW Developed Zone to 4 feet bgs to reduce the likelihood of direct contact by residents and public utility workers

- Excavating surficial TPH impacts on the railyard in addition to metals.

A plan view illustrating the SW4 site-wide remedial alternative is provided in Figure 6-28. This alternative accelerates cleanup in the Levee Aquatic

Resource Zone and removal of free product, and it more permanently addresses direct contact risks.

6.4.2.2 Alternatives With the On-Property, Conditional Groundwater Point of Compliance

The alternatives in this section were developed to meet on-property conditional groundwater POC (i.e., groundwater must achieve cleanup standards as close as practicable to the source without exceeding the BNSF property boundary). Each of the PB alternatives will clean up groundwater from BNSF property to the River. The alternatives are discussed from left to right on Table 6-5 and as you proceed through the discussions below.

Alternative PB1

The cleanup technologies that combine to make up Alternative PB1 are listed on Table 6-5. Alternative PB1 removes free product, complies with groundwater cleanup standards, protects the Skykomish River and Maloney Creek, and provides containment and institutional controls to prevent dermal contact with soil off the railyard (Figure 6-29). This alternative permanently addresses the higher risk pathways of:

- Groundwater and oil discharges to the Skykomish River
- Contaminated surface soil that might be inhaled as dust or might be a direct contact concern

The alternative also looks to address impacts beyond the property boundary by:

- Excavating the South Developed Zone to remove contaminated soil
- Excavating free product from the NW Developed Zone where accessible
- Implementing enhanced bioremediation in the NW Developed Zone

A plan view illustrating the PB1 site-wide remedial alternative is provided in Figure 6-29.

Alternative PB2

The cleanup technologies that combine to make up Alternative PB2 are listed on Table 6-5. Alternative PB2 builds on PB1 by adding the following elements:

- Excavating or grouting of free product in the levee
- Removing impacted surface sediment associated with the free product removal in the levee noted above
- Implementing enhanced bioremediation in the NE Developed Zone
- Using enhanced bioremediation of groundwater at the property boundary to restore groundwater quality in the NW Developed Zone
- Using free product recovery trenches for the interior free product plumes on the Railyard rather than skimming pumps

A plan view illustrating the PB2 site-wide remedial alternative is provided in Figure 6-30.

Alternative PB3

The cleanup technologies that combine to make up Alternative PB3 are listed on Table 6-5. Alternative PB3 builds on PB2 by adding the following elements:

- Excavating, ozone sparging, or flushing free product and impacted soil in the levee
- Removing all contaminated surface sediment in the Skykomish River
- Removing contaminated surface sediment from the Former Maloney Creek channel to the extent that it does not significantly damage the wetland habitat
- Implementing enhanced bioremediation in the Former Maloney Creek Channel to address soil impacts and reduce the potential for recontamination of sediment
- Excavating or flushing all free product in the NW Developed Zone
- Excavating shallow smear zone impacts in the NW Developed Zone to 4 feet bgs to reduce the likelihood of direct contact by residents and public utility workers
- Flushing the 2 northwest free product plumes on the Railyard
- Excavating surficial TPH impacts on the Railyard in addition to metals.

A plan view illustrating the PB3 site-wide remedial alternative is provided in Figure 6-31.

Alternative PB4

The cleanup technologies that combine to make up Alternative PB4 are listed on Table 6-5. Alternative PB4 provides additional action relative to PB3 as follows:

- Excavating all free product and soil impacts in the levee
- Removing all contaminated surface sediment in the former Maloney Creek channel
- Excavating free product in the NE Developed Zone in addition to enhanced bioremediation
- Excavating or flushing all free product and impacted soil associated with groundwater concentrations above cleanup levels
- Excavating or flushing all free product areas on the railyard.

A plan view illustrating the PB4 site-wide remedial alternative is provided in Figure 6-32.

6.4.2.3 Standard Point of Compliance Alternative (STD)

This alternative is included to satisfy the MTCA requirement that one remedial alternative be included in the FS/EIS that achieves cleanup levels for all media at standard POCs. Due to the physical and chemical properties of the petroleum impacts at Skykomish, this alternative relies primarily on excavation of all free product and all impacted soil.

Figure 6-33 shows the layout of these excavations for free product, soil, and sediment. The excavations will be performed to remove all free product, all soil above cleanup levels, and all sediment above cleanup levels. The River and Maloney Creek would be restored, the levee would be rebuilt and structures, roads and utilities would be replaced or rebuilt.